

Major Weapon System Environmental Life-cycle Cost Estimating for Conservation, Cleanup, Compliance and Pollution Prevention (C³P²)

By

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Abstract

The Titan IV Space Launch Vehicle Program is one of many major weapon system programs that have modified acquisition plans and operational procedures to meet new, stringent environmental rules and regulations. The Environmental Protection Agency (EPA) and the Department of Defense (DOD) mandate to reduce the use of ozone depleting chemicals (ODCs) is just one of the regulatory changes that has affected the program. In the last few years, public environmental awareness, coupled with stricter environmental regulations, has created the need for DOD to produce environmental life-cycle cost estimates (ELCCE) for every major weapon system acquisition program. The environmental impact of the weapon system must be assessed and budgeted, considering all costs, from cradle to grave. The Office of the Secretary of Defense (OSD) has proposed that organizations consider Conservation, Cleanup, Compliance and Pollution Prevention (C³P²) issues associated with each acquisition program to assess life-cycle impacts and costs.

The Air Force selected the Titan IV system as the pilot program for estimating life-cycle environmental costs. The estimating task required participants to develop an ELCCE methodology, collect data to test the methodology and produce a credible cost estimate within the DOD C³P² definition. The estimating methodology included using the Program Office weapon system description and work breakdown structure together with operational site and manufacturing plant visits to identify environmental cost drivers. The results of the Titan IV ELCCE process are discussed and expanded to demonstrate how they can be applied to satisfy any life-cycle environmental cost estimating requirement.

The requirement to identify environmental life-cycle costs during the program acquisition phase is rapidly emerging as one of the most significant environmental initiatives of our time. The Department of Defense (DOD) has wholeheartedly embraced the concept and not only sees it as a rational means of safeguarding the environment, but as an effective means of reducing pollution-related costs, sustaining military operations and maintaining a "good neighbor" reputation for environmental compliance.

Environmental compliance and pollution prevention have been mandated by the federal government. Executive Order 12873, October 1993, mandating recycling and pollution prevention, added emphasis to environmental programs already underway. The Federal Facility Compliance Act of 1992 enables the EPA and the states to use the full range of enforcement tools they have at their disposal against a federal facility. All environmental areas, air, water, hazardous waste and solid waste are now addressed from the President down to the user level in all manner of regulations.

Each environmental Act or Executive Order that affects DOD has the potential of impacting the cost of developing, procuring, operating or disposing of a major weapon system. The Department of Defense is actively pursuing methods for evaluating environmental life-cycle cost impacts of major weapon systems. This information will then be included as a part of the milestone approval briefings. The major

objective of this effort is to assure that there are no future environmental funding "surprises", particularly for demilitarization and disposal. The acquisition community, in its attempt to put some discipline into the process, wants managers to make the "best" environmental decisions and then estimate C³P² environmental costs to the end of the life-cycle. The estimating methodology must satisfy current Defense Acquisition Board direction yet be easy to modify to incorporate new environmental rules.

The Air Force Titan IV Space Launch program was selected as the first program for estimating life-cycle C³P² environmental costs. The Titan IV missile, used by DOD, NASA and other customers to launch satellites, is currently undergoing a solid rocket motor upgrade, the reason for the latest review cycle. Launches are scheduled through the year 2004 with two options to extend the program: to 2007 and 2014. The environmental life-cycle cost estimate covered the years 1992 to the end of the program, with 1994 as the base year for the estimate.

The identification of life-cycle environmental issues associated with Conservation, Compliance, Cleanup and Pollution Prevention (C³P²) were required in order to gather the accurate data necessary to produce an accurate cost estimate. No previous examples were available to use as a model for collecting and organizing the data; therefore, a system of data collection, compilation and cost estimating was devised to meet the requirements. The weapon system life-cycle phases from DOD 5000.4M, *Cost Analysis Guidance Procedures*, were used as the baseline for the life-cycle. These are:

- Research and Development
- Manufacturing
- Maintenance and Logistics
- Operations and Support, including demilitarization and disposal
- Facilities, construction or major modifications
- Personnel and Training

The Titan IV cost estimate was prepared from documentation provided by the system program office and data gathered during visits to the operational launch sites and the prime contractor's manufacturing facility. Five other major element contractors were interviewed by telephone to determine the extent of their compliance, pollution prevention, management and training activities. Data was gathered and grouped according to environmental requirements for the program. This enabled the team to stay focused on Titan IV C³P² life-cycle environmental issues.

There are three basic documents that provide adequate detail to support data gathering and the production of an environmental life-cycle cost estimate. These are the operations concept (plan), the maintenance concept and the Work Breakdown Structure (WBS). Other documents, such as a detailed acquisition plan and test and evaluation plan, provide additional details that improve the estimate. The WBS contains all the major elements, components and subcomponents that make up the total system. This includes management, documentation, training and facilities in addition to the actual hardware. The Operations and Maintenance concepts describe how a weapon system will be employed and maintained. Therefore, they provide the data an analyst needs to establish quantities for each WBS element during the operational and disposal phases of the life-cycle.

The next step was to evaluate selected Titan IV WBS elements against the C³P² environmental categories to determine if there were any environmental data associated with the individual elements. Management, which was included in the WBS, and risk were added to C³P² as important environmental cost categories. A procedure similar to that shown in Figure 1 was used to collect and roll-up costs for components and subcomponents. The sum of all individual costs is the total weapon system environmental cost.

Once the methodology was in place, data gathering and cost estimating were straight forward and followed standard procedures. The findings for each C³P² environmental category required personnel to examine environmental regulations as they applied to the WBS elements and activities; that is, the Clean Air Act, Clean Water Act, Federal Facilities Compliance Act, and so forth. The relationships shown in Figure 1 were used to simplify the data collection process. The methodology or process was developed to handle the different types of waste streams associated with manufacturing, operations and demilitarization

and disposal. A summary for each phase of the life-cycle, Design and Acquisition, Operations and Maintenance and Demilitarization and Disposal is provided below.

Compliance data for each principal cost area were gathered from operational launch sites and major component manufactures.

- **Air.** Air regulations and procedures impacting Titan IV environmental cost were: New Rule Development, Permit Application, Emission Calculations, Negotiations with Regulatory Agencies, Recordkeeping, Title V Operating Permit and Title III Maximum Achievable Control Technology. The majority of cost for air compliance was attributed to manpower and permits. Some manufacturers were incurring operational costs for air handling equipment and in limited cases were programming capital outlays for new equipment to meet EPA requirements. The cost of replacing ODCs and other toxic chemical cleaners was captured under pollution prevention.
- **Wastewater.** Wastewater activities at the operational locations were instituted to control the disposal of deluge water remaining in the launch pad flame bucket after each Titan IV launch. At the manufacturing plants, wastewater management was instituted to dispose of contaminated water produced in various operations, such as chemical milling, and to manage storm water runoff. Environmental activities included Sample Coordination, Sample Analysis, Waste Characterization, Labeling, Waste Minimization Activities, Transportation to a Treatment Plant and management recordkeeping operations.
- **Solid Waste Management.** This was judged an operational cost for Titan IV and no life-cycle cost was assessed.
- **Hazardous Materials.** Hazardous materials management was limited to the personnel required to control, inventory and file reports. These costs were included in Management.
- **Hazardous Waste Management.** Hazardous waste management included those activities associated with generating, treatment, storage, waste minimization, recycling and discharge of hazardous waste. Cost drivers were the management time spent reviewing applicable regulations, time to review operational processes and identify hazardous waste generation sources (inventory), the cost of temporary storage facilities, waste characterization, sampling and analysis, labeling, transportation and disposal. The manufacturing facilities incur the largest portion of hazardous waste management costs, primarily for disposal.
- **Noise.** A study to determine the effect of missile launch noise on California marine mammals was the only noise compliance issue associated with the program and was included in the estimate.
- **Special Compliance Reporting.** Compliance reporting costs were captured in the Management Costs.

Pollution Prevention for Titan IV was being practiced by all organizations involved in the program. Recycling and materials substitution programs were in place at all locations queried. In some cases, there were significant cost dividends. Costs were not grouped by category for this evaluation as shown in figure 1, but rather were associated with the appropriate Titan IV WBS element. One exception that was listed separately was a pelletized carbon dioxide degreasing system that was being tested as a replacement for a liquid ODC wipe down process.

Conservation activities have been included as a part of the Titan IV program for many years. Costs associated with preservation of the natural habitat, cultural and archeological resources were consolidated with management data. There are approximately two environmental impact studies and environmental assessments performed per year for the program that were documented in the life-cycle estimate.

Clean-up, or restoration, is accomplished as required during the operational phase of the life-cycle and thoroughly at the end of the program. If pollution prevention and spill control programs have been effective, there will be little clean-up required. The Titan IV program was initiated before today's strict environmental rules were passed and there are environmental hazards that were created early-on in the program that have been, or will have to be, remediated before the program is phased out. Some

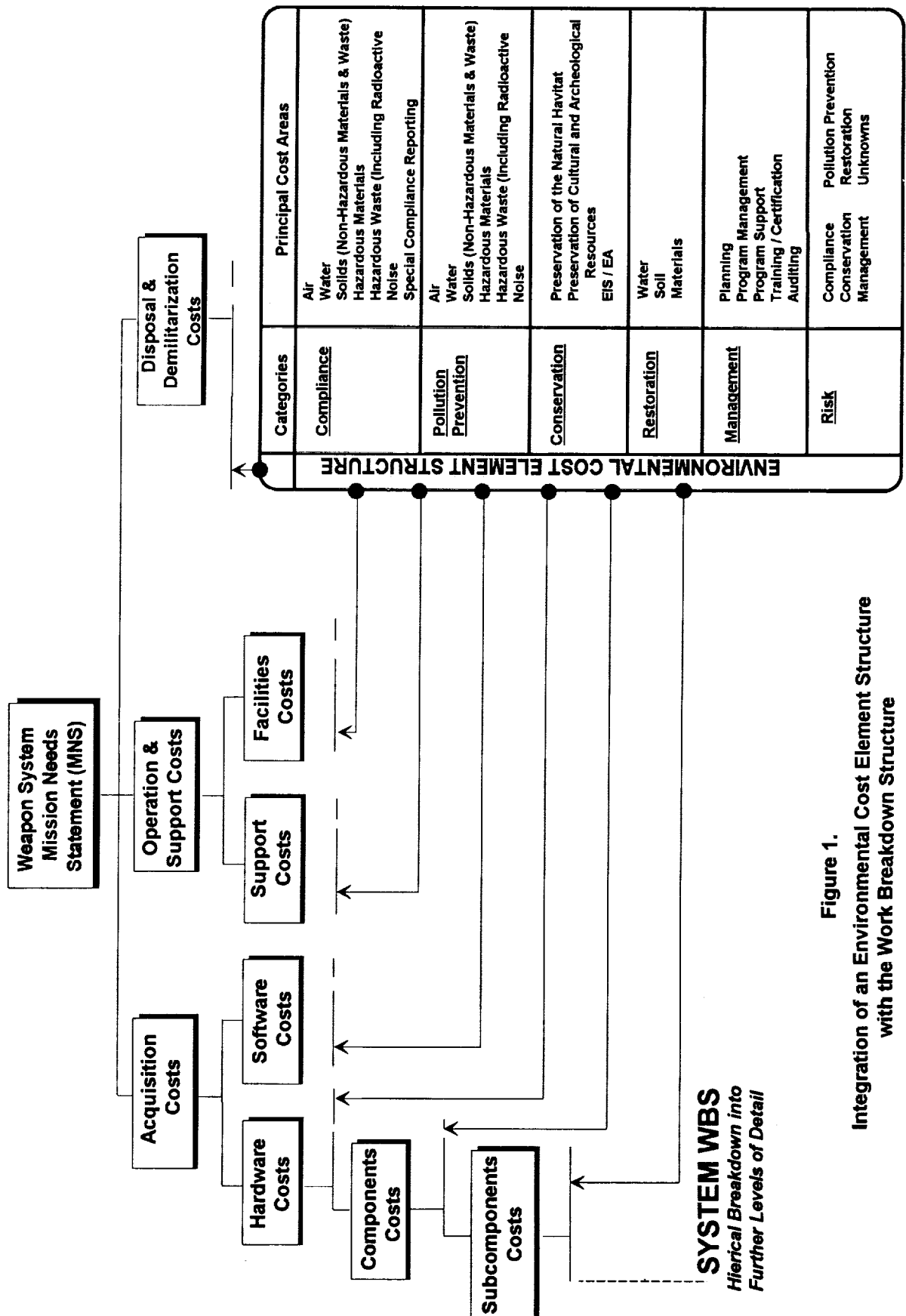


Figure 1.
Integration of an Environmental Cost Element Structure
with the Work Breakdown Structure

manufacturers have installed monitoring wells around their facilities to evaluate ground water pollution in order to take appropriate action. Lead has been detected near one launch site and may have to be cleaned up at the end of the program. The extent of clean-up overall was unknown and estimates were not available. As a result, these estimates were incorporated into the "Risk" estimate.

Management included all of the people activities that could be directly attributed to complying with EPA environmental requirements. Environmental test and evaluation was incorporated into this cost estimating category along with Planning, Program Management, Program Support and Training.

Risk was the estimate of the unknown environmental life-cycle requirements. Where impending changes were identifiable, such as the Maximum Achievable Control Technology enacted in Title III of the Clean Air Act Amendment, a reasonable risk estimate could be made. The environmental rules that are known to be in work but have not been published yet were harder to estimate. Demilitarization and disposal requirements at the end of the program were difficult to quantify. If the expectations of the operations concept are met, all systems will be launched into space. The plans did treat the more hazardous elements, such as the solid propellant boosters that may be converted into mining explosive at phase out. Based on prior experience, risk was estimated to be between 8 and 12 percent of the total environmental cost estimate.

After the individual WBS element estimates were completed the cost was summarized (rolled-up) to produce a single value life-cycle environmental cost estimate for Titan IV. The data showed that cost drivers for operational launch sites and manufacturing facilities were about the same, the only difference being cost magnitude.

A workshop was convened after the Titan IV environmental life-cycle cost estimate was published to evaluate the methodology that was used and to recommend methods for improving and automating the process. The workshop organized the Titan IV methodology and expanded on the data collection procedures by defining the components of environmental cost. The conceptual data collection process and cost estimating methodology is that presented in Figure 1. Environmental life-cycle costs are impacted from the inception of the program as first described in the weapon system requirements document or statement of need. When the requirement is approved by OSD and development begins, the need to evaluate trade-offs and assess environmental life-cycle cost also begins.

The workshop limited the life-cycle to three phases: acquisition, operation and support and disposal and demilitarization. The acquisition phase includes design, development, manufacturing, test and evaluation and system delivery. Operations and support includes daily operations and training, logistics support and maintenance activities. Demilitarization and disposal are the final steps required to remove the weapon system from the Air Force inventory and make all parts safe for disposal or recycling.

Conclusions drawn from the Titan IV effort are that it is difficult to separate out environmental life-cycle costs from other research and development, acquisition and operational costs. Currently the cost of environmental compliance is included in the program as a cost of doing business. However, when weapon systems are modified, as the Titan IV was, the environmental impact of the change must be evaluated. If there are environmental costs added to the program as a result of the change, they must be identified and included in the program to assure adequate funding.

Another result of the Titan IV effort was the recognition that demilitarization and disposal costs have not been adequately accounted for in the phase out of prior weapon systems. Environmental compliance costs associated with demilitarization and disposal must be evaluated separately to submit adequate funding requests for this life-cycle phase. Every weapon system will have some final disposition charges and recycling paybacks that must be introduced into the life-cycle estimate as early as possible in the life-cycle.

Future development plans will build on the Titan IV estimating experience with a technical plan and cost guide being developed. These will build on MIL-STD-881B, Work Breakdown Structure, incorporate data from aircraft and missile cost handbooks, and use existing models for environmental containment costs. Relevant parts of existing environmental cost estimating models will be integrated to build an automated cost analysis tool. The design is based on proven model building methodology with easy incorporation of environmental rule and legislative changes.

The methodology and environmental life-cycle cost estimating procedures used for the Titan IV Space Launch system are not specific to DOD weapon systems. It will work for any system that has well defined components and goes through life cycle phases. It can be used to assess the environmental cost requirements for building and operating automobiles, large equipment, commercial airlines and the like. When the automated environmental life-cycle cost estimating model is in place, the time required to produce an estimate is expected to decrease while the accuracy increases.